

Organic Analysis of Catalytic Fischer-Tropsch Type Synthesis Products: Are they Similar to Organics in Chondritic Meteorites?

Cyriah A. Yazzie¹, Darren R. Locke², and Natasha M. Johnson³

¹Diné College, Tsaile, AZ 86556; ²HX5 – Jacobs JETS Contract, NASA Johnson Space Center, Houston, TX 77058; ³NASA Goddard Space Flight Center, Greenbelt, MD 20771

Fischer-Tropsch Type (FTT) synthesis of organic compounds has been hypothesized to occur in the early solar nebula that formed our Solar System. FTT is a collection of abiotic chemical reactions that convert a mixture of carbon monoxide and hydrogen over nano-catalysts into hydrocarbons and other more complex aromatic compounds. We hypothesized that FTT can generate similar organic compounds as those seen in chondritic meteorites; fragments of asteroids that are characteristic of the early solar system. Specific goals for this project included: 1) determining the effects of different FTT catalyst, reaction temperature, and cycles on organic compounds produced, 2) imaging of organic coatings found on the catalyst, and 3) comparison of organic compounds produced experimentally by FTT synthesis and those found in the ordinary chondrite LL5 Chelyabinsk meteorite. We used Pyrolysis Gas Chromatography Mass Spectrometry (PY-GCMS) to release organic compounds present in experimental FTT and meteorite samples, and Scanning Electron Microscopy (SEM) to take images of organic films on catalyst grains.

Our findings indicate that catalyst, temperature, and FTT cycles play a role in the composition and distribution of reaction products. The Py-GCMS results of the two different catalysts Fe and Fe₃O₄ at a temperature of 600°C and 20 cycles indicates that Fe produces much greater concentrations of aliphatic (e.g. alkene, alkane, alcohol) and aromatic compounds (e.g. alkylbenzenes and naphthalenes, styrene, benzaldehyde) relative to Fe₃O₄. Further, the effect of dropping the temperature to 400°C on the organics produced with Fe₃O₄ after 20 cycles was to increase the aliphatic and aromatic concentrations by several orders of magnitude. The equivalent sample of Fe catalyst at 400°C was unavailable for comparison but is currently being experimentally produced. The result of 1 and 20 FTT cycles on the distribution and concentration of aliphatic and aromatic hydrocarbons with Fe catalyst at 600°C indicates that the same distributions occurs, but the aromatic concentrations after 20 cycles is greater while the aliphatic concentrations remain the same. In comparison, Fe₃O₄ at 400°C with 1 and 20 cycles shows dramatic differences in the distribution and concentrations of both aromatic and aliphatic compounds. Carbon mapping with an SEM indicates that the organics on the cubic shaped Fe₃O₄ grains at 400°C, after 20 cycles, may form clusters in addition to thin films on the grains.

Remarkably, the distribution and concentration of aliphatic and aromatic compounds in the LL5 Chelyabinsk meteorite, as analyzed, processed, and interpreted in this study, are similar to those from FTT synthesis with Fe₃O₄ at 400°C and 1 cycle. This result lends credibility to the hypothesis of FTT synthesis occurring in the early solar nebula.